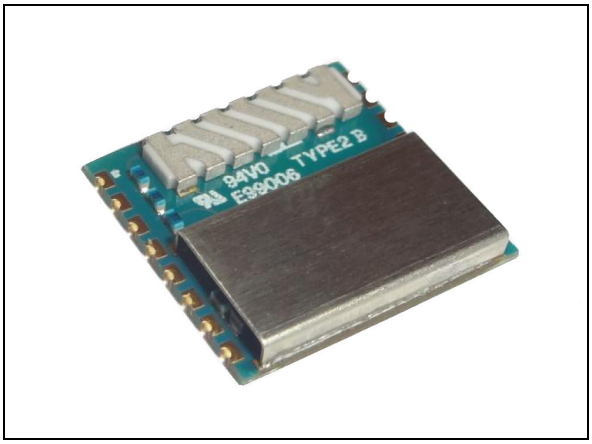
SP1ML

SPIRIT1 868 and 915 MHz low power RF modules with integrated microcontroller

Datasheet - production data



Features

- Complete RF-ready SPIRIT1 module based on:
  - SPIRIT1 low data rate, low power sub-GHz transceiver
  - STM32L1 Ultra low power microcontroller at 32 MHz (32 kB RAM and 128 kB Flash)
  - BALF-SPI-01D3 868/915 MHz balun with integrated harmonic filter
  - Integrated antenna and crystal
- Compact size: 14 mm x 13.4 mm x 2.5 mm
- 863 to 870 MHz operation (SP1ML-868)
- 902 to 928 MHz operation (SP1ML-915)
- Operates from a single 1.8 V to 3.6 V supply
- Output power up to +11.6 dBm
- Data rates up to 500 kbps
- Modulation schemes: 2-FSK, GFSK, GMSK, OOK, and ASK
- Operating temperature: -40 °C to 85 °C
- UART interface with AT command set
- FCC and CE regulatory approvals

Applications

- Home & building automation
- Wireless sensor network
- Data acquisition equipment
- Security systems
- Mobile health and medical
- Industrial monitor and control
- Wireless metering, WMBUS
- Internet of things (IoT)

Description

The SP1ML-868 and SP1ML-915 are ultra-low power & fully integrated RF modules operating respectively in the 868 MHz SRD and 915 MHz ISM bands.

The SP1ML module is a compact-size module, integrating an on-board antenna with easy-to-use interface, allowing users to easily add wireless connectivity in designs without requiring in-depth RF experience, and has all necessary FCC modular approvals and CE compliance, reducing time-to-market.

These modules are based on the SPIRIT1 RF sub-GHz transceiver (with integrated SMPS), STM32L1 microcontroller, integrated filter/balun and chip antenna. The UART host interface allows simple connection to an external microcontroller with a standard firmware, allowing AT commands to facilitate RF configuration, data transmission and reception, using simple point-to-point communication. Selected STM32L1 GPIO and peripherals are available for interfacing to external devices in the user application. Advanced features of the SPIRIT1 radio are also accessible. The serial wire debug interface (SWD) is also available.

The modules are CE compliant and FCC certified (FCC ID S9NSP1ML).

This is information on a product in full production. www.st.com

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1 Hardware specification

General conditions (V_{IN} = 3 V and T_A = 25 °C).

1.1 Recommended operating conditions

Table 1. Recommended operating conditions

Symbol	Parameter	Min.	Typ.	Max.	Unit
T_A	Operating ambient temperature range	-40	-	85	°C
V_{DD}	Operating supply voltage	1.8	3	3.6	V
FREQ	RF frequency (SP1ML-868)	863	-	870	MHz
FREQ	RF frequency (SP1ML-915)	902	-	928	MHz

1.2 Absolute maximum ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Min.	Typ.	Max.	Unit
T_{STG}	Storage temperature range	-40	-	85	°C
V_{DD}	Operating supply voltage	-0.3	-	3.9	V
V_{IO}	I/O pin voltage	-0.3	-	5.5	V

1.3 I/O operating characteristics

Table 3. I/O operating characteristics

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{IL}(1)	I/O input low level voltage	-0.3	-	0.3 V_{DD}	V
V_{IH}(1)	I/O input high level voltage	0.7 V_{IN}	-	V_{DD}+0.3	V

1. For more details see the STM32L151RB datasheet, I/O port characteristics.

1.4 Current consumption

Table 4. Current consumption

Symbol	Parameter	Test conditions	Typ.	Unit
I_{DD}	Supply current	Operating mode Tx, +11 dBm, 2-FSK, 915 MHz	20	mA
		Operating mode Tx, -7 dBm, 2-FSK, 915 MHz	8	mA
		Operating mode Rx, 915 MHz	13.5	mA
		Command mode	2.2	mA
		Standby	1.4	µA

1.5 RF compliance limits

The RF compliance limits are those tested for FCC and CE certification. These limits are enforced by the factory loaded firmware. Care must be taken with custom firmware to ensure these limits are not exceeded, voiding the FCC and CE certification.

Table 5. RF compliance limits

Modulation	Standards	Parameter	Max.	Unit
2-FSK GFSK MSK	FCC Part 15.207 (1) FCC Part 15.247 (1) EN 300 220-2 V2.4.1 (2) EN 301 489-01 V1.9.2 (2) EN 301 489-03 V1.4.1 (2)	Data rate	500	kbps
		Output power	+11.6	dBm
OOK ASK	FCC Part 15.207 (1) FCC Part 15.249 (1) EN 300 220-2 V2.4.1 (2) EN 301 489-01 V1.9.2 (2) EN 301 489-03 V1.4.1 (2)	Data rate	250	kbps
		Output power	+8.5	dBm

1. FCC standards are only applicable to the SP1ML-915 module.
2. EN standards are only applicable to the SP1ML-868 module.

1.6 Pin assignment

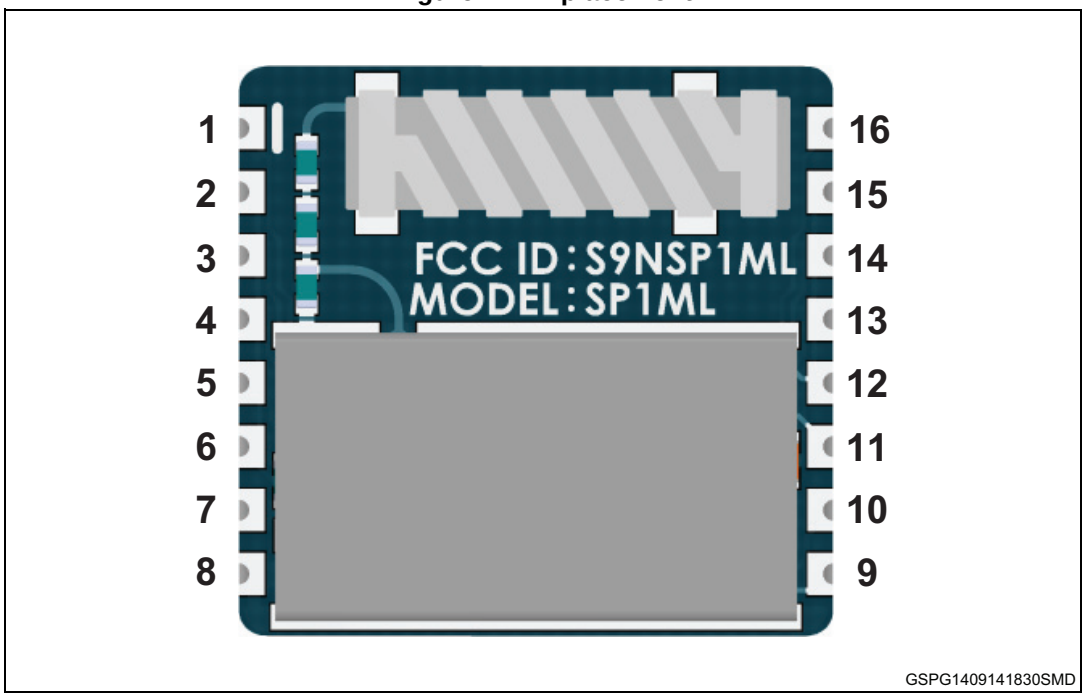
Table 6. Pin assignment

Pin	Name	Type	Description	STM32L pin(1)
1	TXRXLED	O	Active low Tx/Rx LED drive(2)	PA2
2	SHDN	I	Shutdown	PA0
3	GPIO0	I/O	General purpose input/output 0(3)	PB15
4	GPIO1	I/O	General purpose input/output 1 (3)	PB14
5	MODE0	I	Protocol mode selection 0(2)	PB13
6	MODE1	I	Protocol mode selection 1(2)	PB12
7	VDD	Power	Supply input voltage	-
8	GND	Power	Ground	-
9	SWDIO	I/O	Serial wire I/O	PA13
10	SWCLK	I	Serial wire clock	PA14
11	BOOTMODE	I	Boot mode selection	BOOT0
12	RESET	I	Reset input, active low	NRST
13	TXD	O	UART transmit data	PA9
14	RXD	I	UART receive data	PA10
15	GPIO2	I/O	General input/output 2 (3)	PB6
16	GPIO3	I/O	General purpose input/output 3 (3)	PB7

1. For further details, see the STM32L151RB datasheet, Pin descriptions section. Alternate functions of any given pin are dependent on the user application firmware that is loaded into the module and is beyond the scope of this document.
2. Refer to Hardware design section for details regarding TXRXLED and protocol mode selection.
3. The GPIO signals are not used by the default firmware integrated in the module. They are accessible with user application firmware. See note *1.*

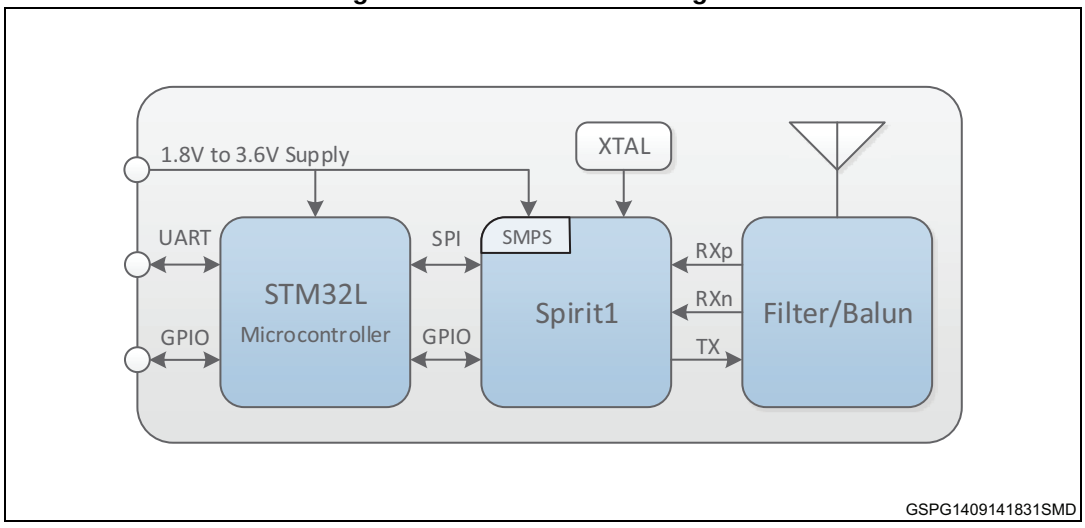
1.7 Pin placement

Figure 1. Pin placement



1.8 Hardware block diagram

Figure 2. Hardware block diagram



2 Hardware design

2.1 Pin usage

If used with the default firmware and interfaced to a host MCU, at a minimum the SP1ML module requires power, ground and UART transmit and receive signals to be connected. Other signals are optional and provide additional functionality. These signals are outlined in *Table 7* below. Unused signals must not be connected.

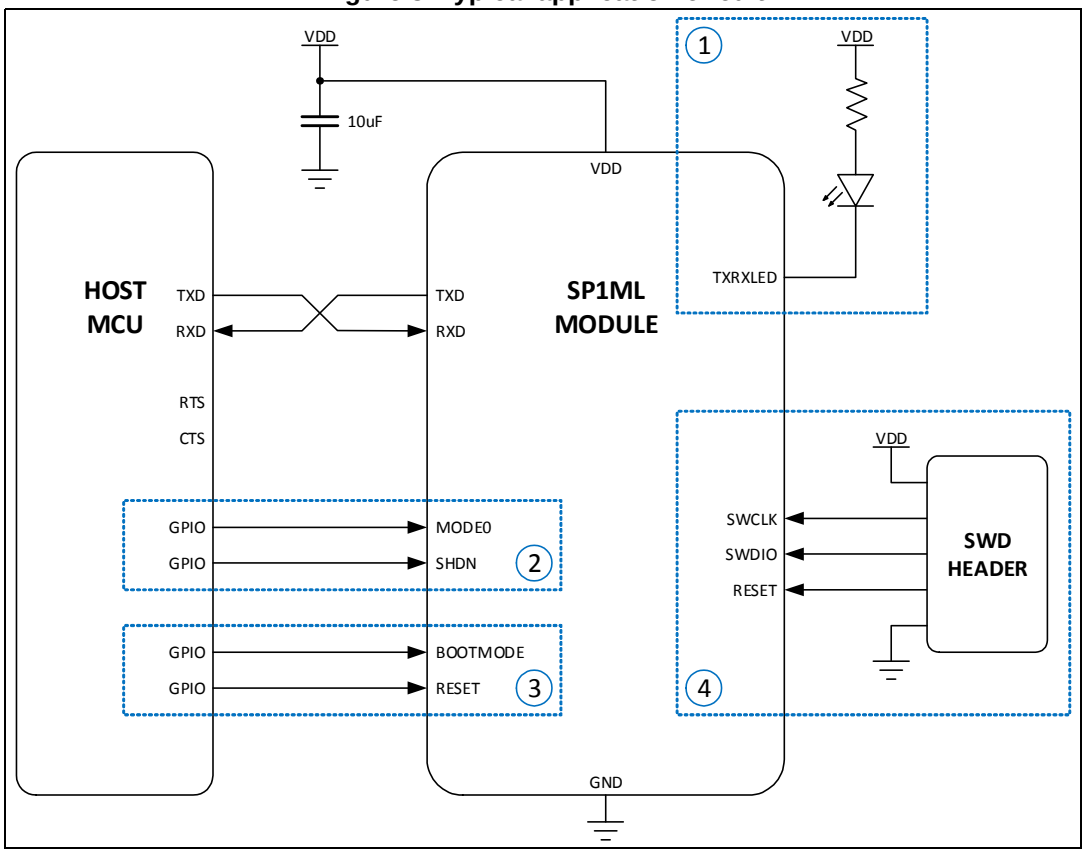
Table 7. Module pin usage

Pin	Name	Description	Optional
1	TXRXLED	An active-low open drain output that can drive an external LED for TX/RX activity status indication. TXRXLED must be enabled by setting the value to 1 in register S24.	Yes
2	SHDN	Drive this signal low to put the module into a low power shutdown mode. Drive the signal high to wake the module.	Yes
3	GPIO0	Reserved for future use, do not connect.	Yes
4	GPIO1	Reserved for future use, do not connect.	Yes
5	MODE0	Drive this signal high to force the module into *operating mode*. Drive this signal low to force the module into *command mode*. This enables faster switching between modes and obviates the need for escape sequences. After setting the MODE0 value, do a RESET to make the new setting effective.	Yes
6	MODE1	Reserved for future use, do not connect.	Yes
7	VDD	Connect to power supply, 1.8V to 3.6V.	No
8	GND	Connect to system ground.	No
9	SWDIO	These signals are the serial wire debug (SWD) interface to the STM32L microcontroller, supporting the development and loading of custom firmware.	Yes
10	SWCLK		Yes
11	BOOTMODE	Drive this signal high at power up or reset to start the boot loader and allow device firmware update over the UART interface.	Yes
12	RESET	Drive this signal low to hold the module in reset. Drive this signal high to release the module from reset.	Yes
13	TXD	Connect to the host system UART RXD input.	No
14	RXD	Connect to the host system UART TXD output.	No
15	GPIO2	Reserved for future use.	Yes
16	GPIO3	Reserved for future use.	Yes

2.2 Typical application circuit

In a typical application the SP1ML module is connected to a host MCU using a standard UART, with transmit and receive signals. This is illustrated in *Figure 3*.

Figure 3. Typical application circuit



Optional functionality

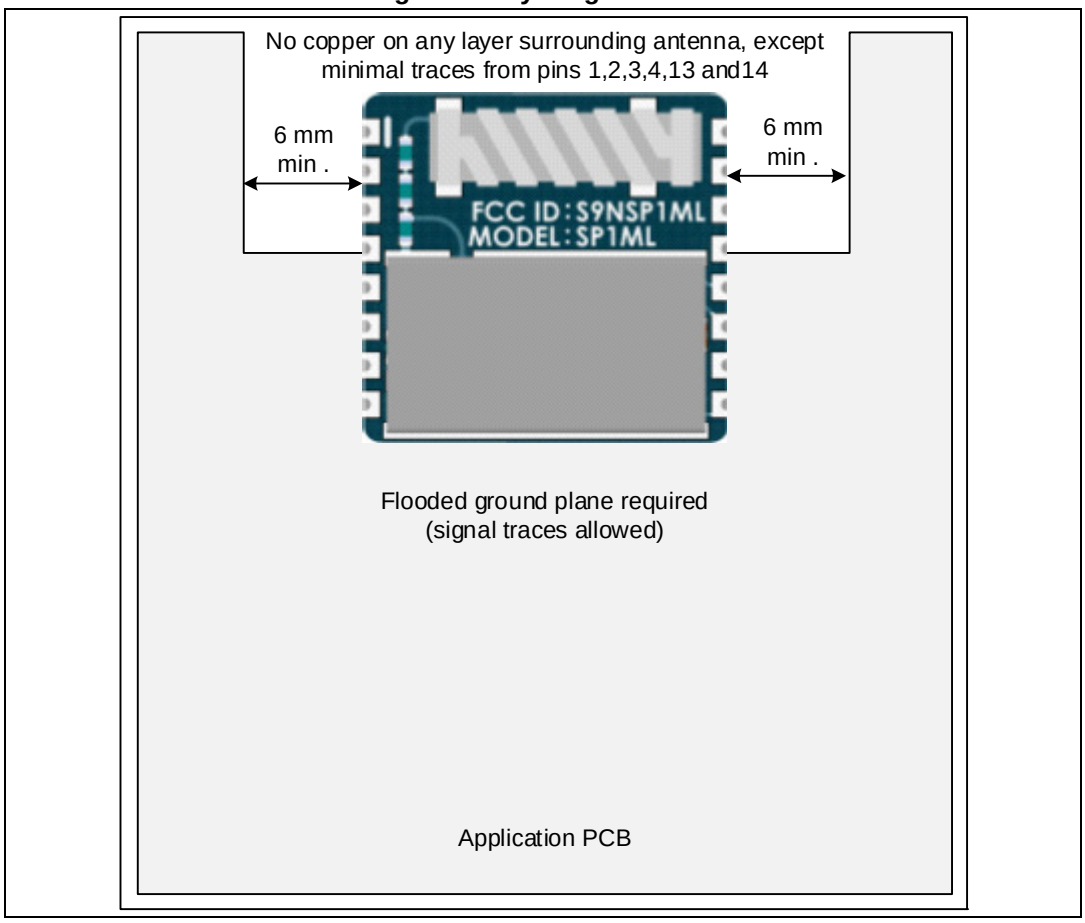
1. When the TXRX_LED (S24) configuration register (see *Table 10*) is set to 1, the TXRXLED signal is an active-low open drain output that can be used to drive an external LED for status indication when data is sent or received.
2. The MODE0 signal provides a hardware method for switching between command and operating modes. The SHDN signal allows the module to be placed into a low power shutdown mode and woken up again.
3. The BOOTMODE AND RESET signals should be connected if module firmware will need to be updated over the UART interface.
4. To support custom module firmware, the serial wire debug signals need to be accessible for programming and debugging.

2.3 Layout guidelines

The application PCB requires a flooded ground plane. Care must be taken to ensure there are no traces or ground planes under the area surrounding the antenna, with the exception

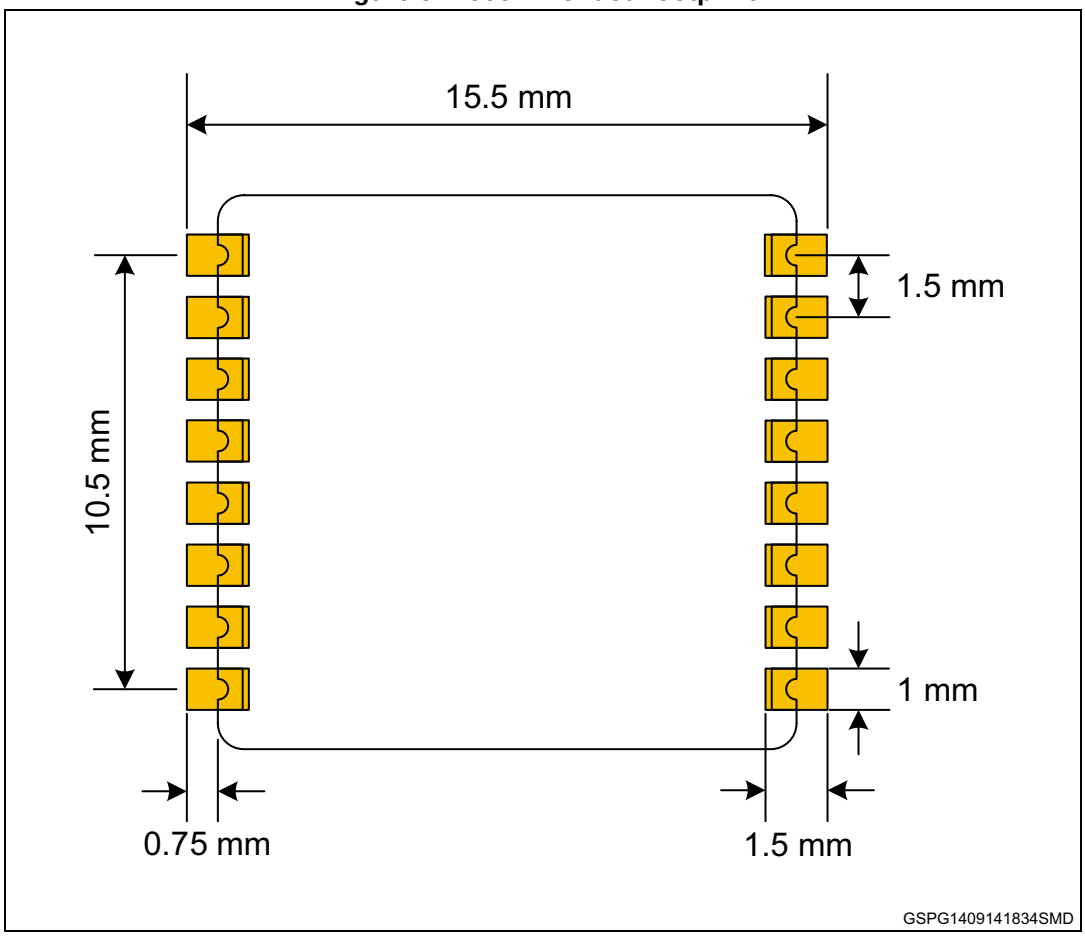
of minimal width traces from pins 1, 2, 3, 4, 13 and 14 of the module if these are used. It is appropriate to place the module toward the edge of the PCB with no traces or ground planes from the antenna to the board edge.

Figure 4. Layout guidelines


No copper on any layer surrounding antenna, except minimal traces from pins 1,2,3,4,13 and14
6 mm min .
6 mm min .
FCC ID:S9NSP1ML
MODEL:SP1ML
Flooded ground plane required (signal traces allowed)
Application PCB

2.4 Recommended footprint

Figure 5. Recommended footprint



2.5 Module reflow installation

The SP1ML is a surface mount module supplied on a 16-pin, 4-layer PCB. The final assembly recommended reflow profile is indicated below, based on IPC/JEDEC JSTD-020C, July 2004 recommendations.

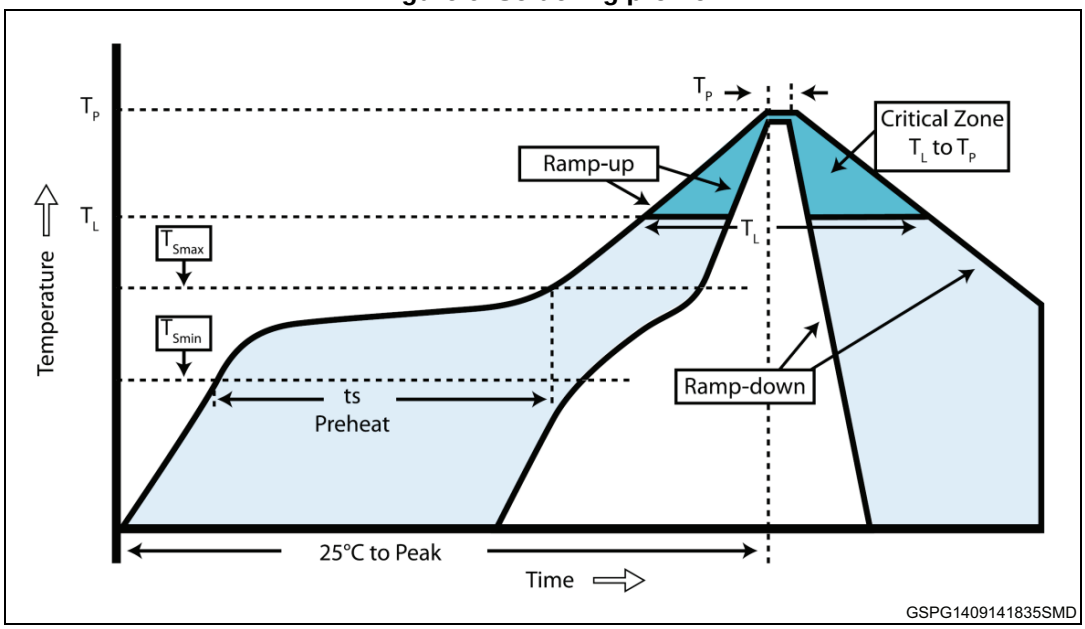
Table 8. Soldering profile

Profile feature	Lead-free assembly
Average ramp-up rate (T_{SMAX} to T_P)	3 °C/sec max
Preheat: – Temperature min. (T_S min.) – Temperature max. (T_S max.) – Time (t_s min. to t_s max.)(t_s)	 150 °C 200 °C 60-100 sec

Table 8. Soldering profile (continued)

Profile feature	Lead-free assembly
Time maintained above: – Temperature T_L – Temperature T_L	 217 °C 60-70 sec
Peak temperature (T_P)	240 °C
Time within 5 °C of actual peak temperature (T_P)	10-20 sec
Ramp-down rate	6 °C/sec
Time from 25 °C to peak temperature	8 minutes max.

Figure 6. Soldering profile



3 Module operation

The SP1ML module is provided with firmware that supports wireless serial cable replacement. There are two operational modes, *command mode* and *operating mode*. The command mode allows module configuration and status interrogation using an extended ‘AT’ style command set. In operating mode the module serves its primary purpose as a wireless transceiver. Following power-up or reset, the module starts in operating mode with the current configuration loaded from EEPROM.

3.1 Operating mode

In operating mode, data received from the host on the UART interface will be wirelessly transmitted by the SPIRIT1 radio using the current configuration settings for frequency, data rate, modulation and output power. Conversely, any data received by the SPIRIT1 that meets the configured filtering criteria will be output to the UART interface.

Care must be taken to ensure that the escape sequence to enter command mode does not occur in the data stream sent by the host to the UART interface.

3.2 Command mode

In command mode, the module will accept commands to configure module settings and interrogate module status. To enter command mode, the ‘+++’ escape sequence is issued to the module from operating mode. The escape sequence should be preceded by minimum delay of 500 milliseconds where no other data is transmitted. The three ‘+’ characters of the sequence must be sent within 500 milliseconds of each other. The module issues the response ‘OK’ if command mode is entered successfully.

Commands issued to the module are in ‘AT’ style format, and use ASCII characters, starting with ‘A’ and ‘T’, then one or more characters for the specific command, followed by any additional command specific data and terminated with a carriage return <CR>.

The delay between each consecutive character of a command must be less than 8 seconds, else the module will time out and discard any characters already received.

If the module receives an invalid command, it will send the ‘ERROR’ response. All responses issued by the module are terminated with a line feed and carriage return, <LF><CR>.

3.3 Command reference

Table 9: Command reference provides a summary of the AT commands available for module configuration. A detailed description of each command is provided following the list.

Table 9. Command reference

Command	Description
ATO	***Enter operating mode*** This command is issued to exit command mode and enter operating mode where the module fulfills its primary purpose as a wireless transceiver using the current configuration. *Response:* **OK**
AT/V	***Read module version information*** Reports the module hardware and firmware version information. *Response:* **SP1ML-xxx HW:Vy FW:Vy.zz** Where **xxx** is 868 or 915, **y** is a single digit major version number and **zz** is a double digit minor version number.
ATIn	***Read an information register*** Reads the current value from an information register, where **n** is the information register number. See information registers table. *Response:* **<REGISTER NUMBER>:<REGISTER NAME>=<VALUE>** **ERROR PARAM** if an invalid register is specified.
ATSnn?	***Read a configuration register*** Reads the current value from a configuration register, where **nn** is the configuration register number. See configuration registers section. *Response:* **<REGISTER NUMBER>:<REGISTER NAME>=<VALUE>** **ERROR PARAM** if an invalid register number is specified.
ATSnn=x	***Write a configuration register*** Writes a new value to a configuration register, where **nn** is the configuration register number and **x** is the value. The new configuration will be in effect until the next module reset. See configuration registers section. *Response:* **OK** if the value is written successfully. **ERROR PARAM** if an invalid register number is specified. **ERROR VALUE** if an invalid value is specified.
AT/S	***Read all configuration registers*** Reads the current values of all configuration registers. See the configuration registers section. *Response: (one line for each register)* **<REGISTER NUMBER>:<REGISTER NAME>=<VALUE>**
AT/C	***Store the current configuration*** Stores the current module configuration registers. The stored configuration will be reloaded anytime the module is reset. *Response:* **OK** if the configuration is stored successfully. **ERROR** if storing the configuration failed.

Table 9. Command reference (continued)

Command	Description
ATR	***Reset configuration to the default values*** This command resets all module configuration registers to their factory default values. *Response:* **OK** **ERROR** if resetting the configuration failed.
ATZ	***Restart the module*** Restarts the module and reloads the current configuration. This generates a soft reset of the microcontroller and start execution of the firmware from the reset vector. *Response:* **OK**
AT/SRnn?	***Read a SPIRIT1 radio register*** Reads the current value from a SPIRIT1 radio register, where **nn** is the two digit hexadecimal register address. *Response:* **<ADDRESS>=<VALUE>** **ERROR PARAM** if an invalid register number is specified. **ERROR** if reading the register failed.
AT/SRnn=xx	***Write a SPIRIT1 radio register*** Writes a new value to a SPIRIT1 radio register, where **nn** is the two digit hexadecimal register address and **xx** is the two digit hexadecimal value to write. *Response:* **OK** **ERROR PARAM** if an invalid register number is specified. **ERROR** if writing the register failed.
AT/Tn	***Set RF test mode*** Set the RF test mode, where **n** is the test mode number from one of the following options: 0 = Disable RF test mode. 1 = Pseudorandom binary sequence RF test mode (PN9). 2 = Continuous wave RF test mode (CW). *Response:* **OK** if the test mode is set successfully **ERROR PARAM** if an invalid test mode number is specified.

3.4 Configuration registers

The configuration registers contain the radio, packet and general configuration settings for the module. They are read and written in command mode. *Table 10* details each configuration register.

Table 10. Configuration registers

#	Name	Description
S00	BAUD_RATE	**General:** Baud rate of the UART interface in *bps*. The baud rate is stored when the configuration is stored. *Values:* Most standard baud rates from 9600 to 921600. *Default:* 115200
S01	FREQUENCY	**Radio:** Frequency in *Hz*. Values: Must be within the operating frequency range of the module. Default: 868000000 (for SP1ML-868) 915000000 (for SP1ML-915)
S02	DATA_RATE	**Radio:** Data rate in *bps*. The data rate for OOK and ASK modulation schemes is limited to 250000bps. Values: From 1000 to 500000 *Default:* 38400
S03	MODULATION	**Radio:** Modulation scheme. *Values:* 0 = 2-FSK 1 = GFSK05 2 = GFSK1 3 = GMSK 4 = OOK 5 = ASK *Default:* 0
S04	OUTPUT_POWER	**Radio:** Output power in *dBm*. *Values:* -34 to +11.6 *Default:* +11.6
S05	FREQ_DEVIATION	**Radio:** Frequency deviation in *kHz*. *Values:* Up to 732 *Default:* 20
S06	RX_FILTER	**Radio:** RX digital filter cutoff frequency in *kHz*. *Values:* Up to 769 *Default:* 100
S07	CS_MODE	**Radio:** Carrier sense mode. *Values:* 0 = Static sensing 1 = Dynamic sensing with 6 dB dynamic threshold 2 = Dynamic sensing with 12 dB dynamic threshold 3 = Dynamic sensing with 18 dB dynamic threshold *Default:* 0

Table 10. Configuration registers (continued)

#	Name	Description
S08	RSSI_THRESHOLD	**Radio:** Carrier sense RSSI threshold in *dBm*. *Values:* -130 to -3 *Default:* -130
S09	PREAMBLE_LEN	**Packet:** Preamble length in *bytes*. *Values:* 1 to 32 bytes. *Default:* 8
S10	SYNC_LENGTH	**Packet:** Sync length in *bytes*. *Values:* 1 to 4 *Default:* 4
S11	SYNC_VALUE	**Packet:** 32-bit sync value. *Values:* Any 32-bit hexadecimal value. *Default:* 0x88888888
S12	CRC_MODE	**Packet:** CRC mode. *Values:* 1 = POLY_0x07 2 = POLY_0x8005 3 = POLY_0x1021 4 = POLY_0x864CFB *Default:* 2
S13	WHITENING	**Packet:** Data whitening mode. Values: 0 = Disabled 1 = Enabled *Default:* 1
S14	FEC	**Packet:** Forward error correction. *Values:* 0 = Disabled 1 = Enabled *Default:* 0
S15	SOURCE_ADDR	**Address:** The 8-bit address for the module, used to indicate the source of transmitted packets and for destination filtering of received packets. *Values:* Any 8-bit hexadecimal value. *Default:* 0x00
S16	DESTINATION_ADDR	**Address:** The 8-bit destination address, used to indicate the destination for transmitted packets and for source filtering of received packets. *Values:* Any 8-bit hexadecimal value. *Default:* 0xff
S17	MULTICAST_ADDR	**Address:** The 8-bit multicast address, used for multicast filtering on received packets. *Values:* Any 8-bit hexadecimal value. *Default:* 0xee

Table 10. Configuration registers (continued)

#	Name	Description
S18	BROADCAST_ADDR	**Address:** The 8-bit broadcast address, used for broadcast filtering on received packets. *Values:* Any 8-bit hexadecimal value. *Default:* 0xff
S19	FILTER_CRC	**Address:** Filter packets that have an invalid CRC. *Values:* 0 = Disabled, 1 = Enabled *Default:* 0
S20	FILTER_SOURCE	**Address:** Filter packets that do not have a source address that matches the address specified in register S16. *Values:* 0 = Disabled, 1 = Enabled *Default:* 0
S21	FILTER_DESTINATION	**Address:** Filter packets that do not have a destination address that matches the modules source address specified in register S15. *Values:* 0 = Disabled, 1 = Enabled *Default:* 0
S22	FILTER_MULTICAST	**Address:** Filter packets that do not have a destination address that matches the multicast address in specified in register S17. *Values:* 0 = Disabled, 1 = Enabled *Default:* 0
S23	FILTER_BROADCAST	**Address:** Filter packets that do not have a destination address that matches the broadcast address in specified in register S18. *Values:* 0 = Disabled, 1 = Enabled *Default:* 0
S24	TXRX_LED	**General:** Enable or disable the TX/RX LED output on module pin 1. When enabled, the LED output will be flashed when data is sent or received by the radio. *Values:* 0 = Disabled, 1 = Active-Low Open Drain Output, 2 = Push Pull Output *Default:* 0
S26	ESCAPE_SEQ	**General:** Enable or disable the '+++' escape sequence used to enter command mode. This configuration is never stored and will be enabled at module reset. *Values:* 0 = Disabled, 1 = Enabled *Default:* 1

Table 10. Configuration registers (continued)

#	Name	Description
S27	Source_FILT_MASK	**Address:** An 8-bit source filter mask, used when source filtering is enabled. Values: Any 8-bit hexadecimal value. Default: 0x00
S28	PAYLOAD_SIZE	**Packet:** Packet payload size in bytes. Values: 1 to 96 Default: 32

3.5 Information registers

Table 11. Information registers

#	Name	Description
I0	PER	Packet error rate (%).
I1	RSSI	Received signal strength indicator.
I2	LQI	Link quality indicator.
I3	PQI	Preamble quality indicator.
I4	SQI	Synchronization quality indicator.
I5	PACKET_COUNT	Count of packets received.
I6	PACKETS_LOST	Count of packets lost.

3.6 Example command sequence

Table 12 shows a typical command sequence to enter command mode, issue AT commands to configure settings of the SPIRIT1 radio and then exit back to operating mode.

Table 12. Example configuration AT sequence

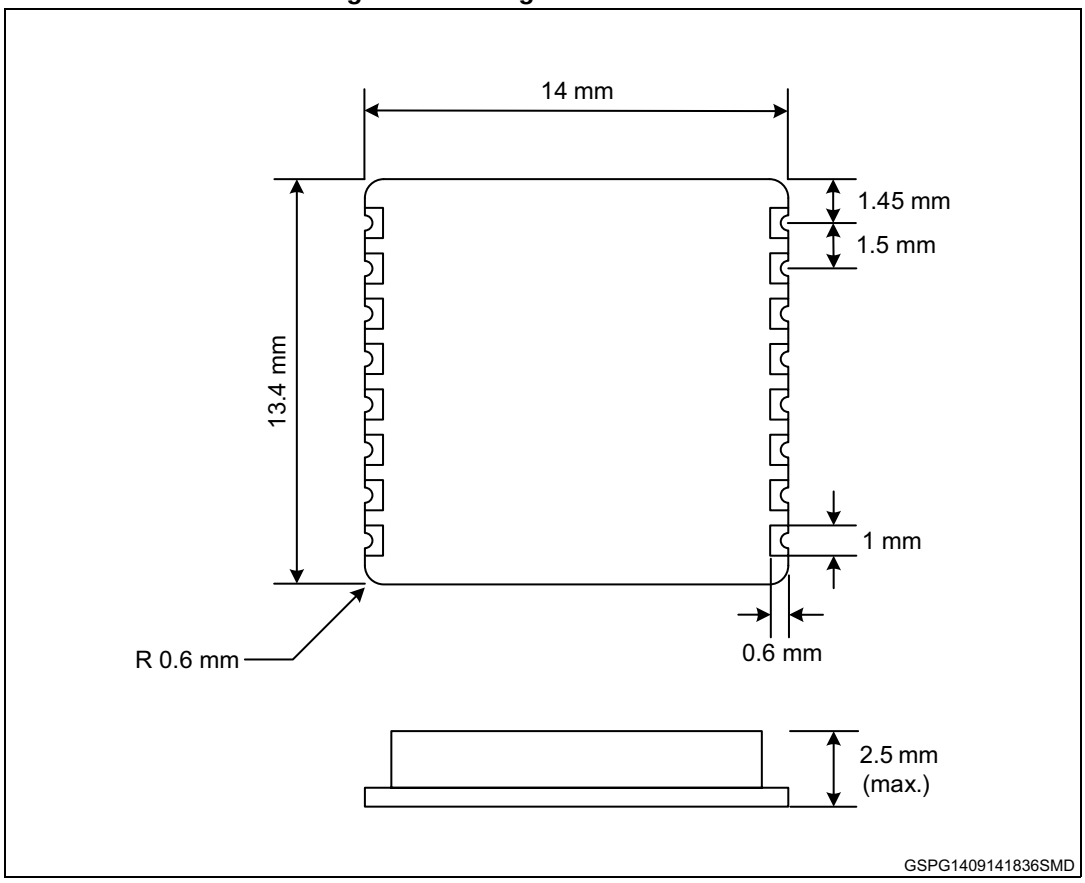
Host command	Module response	Description
+++	**OK**<LF><CR>	Escape sequence to put module into command mode from operating mode.
ATS02=38400	**OK**<LF><CR>	Set the radio data rate to 38400 bps.
ATS03=2	**OK**<LF><CR>	Set the modulation scheme to GFSK1.
ATS04=+8	**OK**<LF><CR>	Set the output power to +8 dBm.
AT/C	**OK**<LF><CR>	Write configuration to EEPROM.
ATO	**OK**<LF><CR>	Return to operating mode.

4 ECOPACK®

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*. ECOPACK® is an ST trademark.

5 Package mechanical data

Figure 7. Package mechanical data



6 Regulatory compliance

6.1 CE certification

The module has been certified in accordance with the following standards:

EN 300 220-2 V2.4.1

EN 301 489-01 V1.9.2

EN 301 489-03 V1.4.1

6.2 FCC certification

This module has been tested and found to comply with the FCC part 15 rules. These limits are designed to provide reasonable protection against harmful interference in approved installations. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

However, there is no guarantee that interference may not occur in a particular installation.

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Modifications or changes to this equipment not expressly approved by STMicroelectronics may render void the user's authority to operate this equipment.

Modular approval

FCC ID: S9NSP1ML

In accordance with FCC part 15, the SP1ML-915 is listed as a modular transmitter device.

This module is evaluated for stand-alone use only. Finished products incorporating multiple transmitters must comply with collocation and RF exposure requirements in accordance with FCC multi-transmitter product procedures. Collocated transmitters operating in portable RF exposure conditions (e.g. <20 cm from persons including but not limited to body-worn and hand-held devices) may require separate approval.

6.3 Labeling instructions

When integrating the SP1ML-915 into the final product, the OEM must ensure that the FCC labeling requirements are satisfied. A statement must be included on the exterior of the final product which indicates the product includes a certified module. The label should state the following (or similar wording that conveys the same meaning):

Contains FCC ID: S9NSP1ML

OR

This product contains FCC ID: S9NSP1ML

The OEM must include the following statements on the exterior of the final product unless the product is too small (e.g. less than 4 x 4 inches):

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including any interference that may cause undesired operation.

6.4 Product manual instructions

This section applies to OEM final products containing the SP1ML-915 module, subject to FCC compliance. The final product manual must contain the following statement (or a similar statement that conveys the same meaning):

WARNING: Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment

In cases where an OEM seeks Class B (residential) limits for the final product, the following statement must be included in the final product manual:

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

In cases where an OEM seeks the lesser category of a Class A digital device for the final product, the following statement must be included in the final product manual:

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his expense.

7 Ordering Information

Table 13. Ordering information

Order code	Description
SP1ML-868	868 MHz SPIRIT1 antenna module (Region 1, Europe)
SP1ML-915	915 MHz SPIRIT1 antenna module (Region 2, The Americas)

8 Revision history

Table 14. Document revision history

Date	Revision	Changes
24-Oct-2014	1	Initial release.
17-Dec-2014	2	– Document status promoted from preliminary to production data. – Updated operating temperature range in *Features* and *Table 1*.
27-Apr-2015	3	Updated: *Features* and *Description*.

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